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August 1980

ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL AIRCRAFT

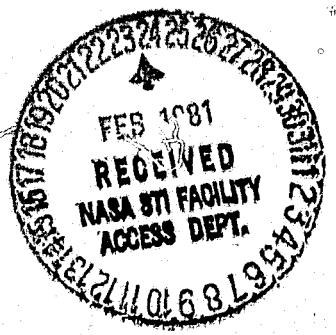
by Daniel J. Hoffman

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LANGLEY RESEARCH CENTER

HAMPTON, VIRGINIA 23665



Under Contract NAS1-15148

by

THE BOEING COMMERCIAL AIRPLANE COMPANY

P.O. BOX 3707

SEATTLE, WASHINGTON 98124

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FOREWORD

This report was prepared by the Boeing Commercial Airplane Company, Seattle, Washington, under Contract NAS1-15148. It is the ninth quarterly technical progress report covering work performed between 1 November 1979 and 30 August 1980 . Boeing regrets any incovenience that this longer than normal reporting interval may have caused. The regular quarterly reporting schedule will resume with this report. Due to the length of time since the last report, some data has been republished in this report to provide continuity. The program is sponsored by the National Aeronautics and Space Administration, Langley Research Center. Mr. Andrew J. Chapman and Mr. Ronald K. Clark are the NASA Technical Representatives.

This contract is being performed by the Advanced Structural Concepts organization. Key personnel associated with the program during the reporting period and their area of reponsibility are:

J. E. McCarty	-- Program Manager
D. J. Hoffman	-- Technical Leader
M. N. Gibbins	-- Analysis
M. W. Ledbury	-- Materials
R. T. Cook	-- Quality Assurance
J. S. Chen	-- Chemical Analysis

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D. J. Hoffman
BOEING COMMERCIAL AIRPLANE COMPANY

1.0 SUMMARY AND PROGRAM STATUS

The period's activities were highlighted by the initial Task I and Task II post exposure residual strength testing. The majority of the effort during this period was devoted to fabricating and recording physical properties on the AS1/3501-6 and Kevlar 49/F161-188 test specimens. The majority of this task has been completed. Additional Task III post exposure testing also took place.

Southwest Airlines has completed deployment of all the Task I and Task II specimens delivered to them. Aloha Airlines has deployed 3 year Task I specimens. A summary update of the long term specimen exposure data is contained in the body of the report. The short beam specimens returned from the NASA Dryden and Honlulu ground racks as well as the Aloha airplane showed lower results than had been expected. The other configurations showed less change.

The initial post exposure testing was conducted on specimens removed from the ground-air-ground simulation chamber. The results show some strength loss. Photomicrographs show that these specimens are not cracking in the freeze thaw environment. The observed strength reductions are probably due to moisture content in the specimens.

Activities during the next quarter will include completion of fabrication efforts required to deploy the Kevlar and AS1/3501-6 specimens, receipt and testing of nominal 1 year Task I and Task II specimens from New Zealand, testing of a second set of Weatherometer exposed specimens, continued analyis of the data assembled to date, and continued exposure of Task I, Task II, and Task III currently deployed.

2.0 INTRODUCTION

The introduction of any new material system into commercial aircraft structure requires that an information data base be available to the designer in such a form that he can accept the material as a viable alternate to the current material system in use. Composite material components on aircraft in scheduled commercial service have demonstrated a viable level of confidence in current design and fabrication methods. In spite of this, the long term durability of composites exposed to actual aircraft operational environments represents a significant unknown in assessing the risk level for a production commitment to primary aircraft structure.

This contract will focus on expanding the data base for composite materials' properties as they are affected by the environments encountered in operating conditions, both in flight and at ground terminals. It is well known that absorbed moisture will degrade the mechanical properties of graphite/epoxy laminates at elevated temperatures. Since aircraft components are frequently exposed to atomospheric moisture, rain, and accumulated water, quantitive data are required showing the amount of fluids absorbed under various environmental conditions. In addition, accelerated laboratory test techniques must be developed that are reliably capable of predicting long term behavior. The study will include a task to develop an accelerated environmental exposure testing procedure and to correlate all experimental results and compare with analytical results to establish the level of confidence for predicting composite material properties.

The overall program has a duration of approximately 11 years and is performed in three tasks as follows:

- Task I - Flight Exposure
- Task II - Ground Based Exposure
- Task III - Accelerated Environmental Effects and Data Correlation

Among the parameters to be investigated are: geographic location, flight profiles, solar heating effects, ultraviolet degradation, retrieval times, specimen types, test temperatures, and others. The experimental program includes in-flight and ground exposures of up to 10 years and will obtain mechanical, physical, and chemical data from about 17,000 specimens. A complete description of the program content was given in the first Quarterly Report (Reference 1). Other reports (References 2-8) have covered progress to date. The overall program is summarized schematically in Figure 2-1. The program schedule is shown in Figure 2-2.

ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERICAL TRANSPORT AIRCRAFT

- FIVE MATERIAL SYSTEMS
- LONG TERM GROUND & FLIGHT EXPOSURE DATA
- ACCELERATED LABORATORY DATA
- DURABILITY MODEL & ACCELERATED TEST PROCEDURES

TASK I FLIGHT EXPOSURE

- CONFIDENCE THROUGH LONG TERM EXPOSURE DATA
- INTERIOR AND EXTERIOR EXPOSURE ON THREE DIFFERENT AIRLINES FOR TIMES UP TO TEN YEARS
- OVER 5300 SPECIMENS

TASK II GROUND EXPOSURE

- CONFIDENCE THROUGH LONG TERM EXPOSURE DATA
- SOLAR AND NONSOLAR EXPOSURE AT FOUR DIFFERENT GROUND STATIONS FOR TIMES UP TO TEN YEARS
- OVER 5300 SPECIMENS

TASK III ACCELERATED ENVIRONMENTAL EFFECTS AND DATA CORRELATION

- BASELINE TESTING
- ACCELERATED TESTS TO LOOK AT THE EFFECTS OF TIME, TEMPERATURE, STRESS, MOISTURE, WEATHEROMETER, AND GROUND-AIR-GROUND SIMULATION
- OVER 4300 SPECIMENS
- ANALYTICAL MODEL FOR DURABILITY PREDICTION
- RECOMMENDED ACCELERATED TEST PROCEDURES FOR EVALUATING ENVIRONMENTAL RESISTANCE

FIGURE 2-1. Program Content

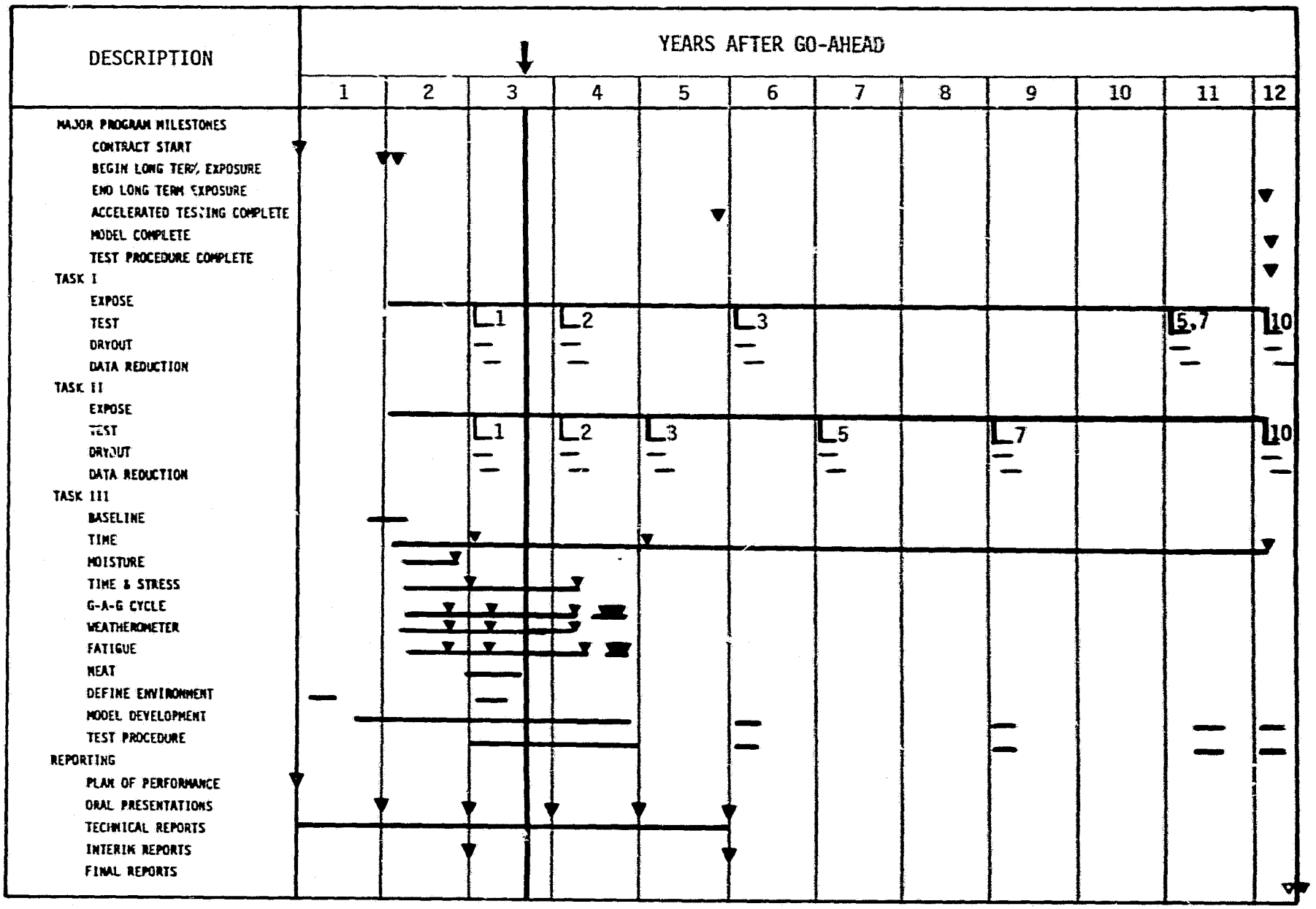


Figure 2-2. Program Schedule

3.0 DESIGN

Test specimen drawings to accomodate the Hercules AS1/3501-6 and Hexcel Kevlar 49/F161-108 material systems have been completed. Only minor changes were invovled in the flexure, short beam shear, and shear exposure specimens, therefore the drawings covering the original three material systems were simply revised to reflect the changes. The overall size of these three specimen types remains the same. The most significant change is in the number of plies and the ply stacking sequence for the Kevlar system. Since the Kevlar ply thickness is less than the ply thickness of the graphite-epoxy systems, additional plies were used in the Kevlar laminates. For example, the Kevlar short beam shear specimens required 32 plies compared to 20 plies for the graphite/epoxy materials. The updated short beam shear and shear exposure specimen drawing is shown in Figure A-1 of the appendix. The updated flexure specimen drawing appears in Figure A-2.

A new drawing was made for the tension specimens as more extensive changes were made to this configuration. It had been decided that the bow tie specimen configuration did not significantly affect the response of the $\pm 45^{0}$ tension tests. Therefore, the specimens for the AS1/3501 and Kevlar material systems will be a constant width, (1.0 inch). The 0^{0} (or 0^{0}-90^{0} for Kevlar fabric) tension specimens will be 0.5 inches wide, straight sided and tabbed for both material systems. The first three graphite systems were designed to be an untabbed bow tie with a 0.5 inch waist. Tabs were added to these specimens when it was observed that the specimens were splitting in the taper region. The tabs provided the desired failure strengths. Use of the tabs obviates the need for the bow tie shape. The new tension specimen drawing appears as Figure A-3.

The AS1/3501-6 compression specimen will be of the same IITRI configuration as was used on the earlier graphite-epoxy materials. The Kevlar compression specimens, on the other hand, will have a substantially different configuration. Testing was done on various compression specimen configurations and reported in the Eighth Quarterly Report. It was decided to use the dual specimen approach specified in BMS 8-218. Both modulus and strength specimens will be used for Task III, while only strength specimens will be used for Tasks I and II. Figure A-4 shows both the AS1/3501-6 and Kevlar compression specimens.

Other minor changes to the test specimen drawings include the paint callout and specimen hole diameters. The paint callout on all previous specimen drawings was discovered to be in error during the initial specimen fabrication. (The correct paint specification was used during the fabrication). The drawing correction is being made now as a convenience while the other drawing revisions are being incorporated. Also, it was determined that the drilled holes in the

$\pm 45^{0}$ tension specimens were marginally small, occasionally resulting in difficulty during the mounting procedure. The hole diameters for the untabbed specimens have been increased from 0.188 inches to 0.1925 inches, and the hole diameter in the specimens with titanium tabs has been increased to 0.257 inches.

No major changes were made to the test specimen holding fixture drawings. Short beam shear/flexure and compression fixtures used in the Task II ground deployment will be made from aluminum instead of titanium as a cost saving measure. The aluminum ground rack insert panels observed to date indicate that this material will perform satisfactorily in this application. One drawing change for the non-solar ground rack insert panels was necessitated by the new Kevlar compression specimen. This was discussed fully in the Eighth Quarterly Report.

4.0 FABRICATION

A second shipment of the Hercules AS1/3501-6 graphite-epoxy system was received and submitted to receiving inspection tests. A summary of the results is shown in Table 4-1. This system was inspected to a modified version of BMS 8-212, "Epoxy Preimpregnated Graphite Tapes and Woven Fabrics -350°F (177 C) Cure". The use of the modified specification is the same procedure used earlier with the Narmco 5209 system.

The values shown in Table 4-1 generally meet the requirements of BMS 8-212. The measured resin content is slightly high. Hercules had indicated that the product purchased for use on the program was normally produced to a wider resin content range than that allowed within BMS 8-212. Also, compression strength was not made a part of the receiving inspection tests. It had been determined earlier that this material system would probably not meet BMS 8-212 requirements in this area. The Hercules system was considered acceptable based on the results shown in Table 4-1.

Following acceptance, a total of ten laminates with various ply stacking sequences were fabricated. Their quality was verified by standard process control tests as well as through transmission ultrasonic non-destructive inspection. These laminates should have provided sufficient stock to machine all of the 2750 required contract specimens. Machining errors caused shortages in three configurations. The contract plan called for fabrication of 25% more (of each specimen configuration), than originally required for deployment. This excess was to be held in reserve for contingencies or future test planning. The machining errors resulted in a minor shortage of stressed $\pm 45^{\circ}$ tension specimens that was easily accomodated by the 25% excess.

The 0° compression specimens and the flexure specimens suffered more serious shortages. The 0° compression specimens resulting from machining were 26% less than required for the initial deployment. The flexure specimen count permits the initial deployment but allows no excess. Discussions have been held with NASA regarding the shortages and it has been decided to make the missing specimens with a new batch of material. The original program plan called for elimination of material batch effects. Remaking these specimens will permit a selective look at batch to batch variability.

The deployment scheme with the additional specimens will have one room temperature and one elevated temperature specimen in each long term fixture. These specimens will always have a -1 for room temperature test and a -6 for elevated temperature test. In this way, the batch to batch affects can be checked when sufficient data

has been received. All Task III testing will be accomplished with specimens from the original batch. It is considered unlikely that a significant batch to batch variation will exist. In the event that it does, sufficient specimens will exist in the second batch to conduct some laboratory investigation.

Following machining, the individual graphite/epoxy specimens are weighed and measured. Task I and II specimens are then painted and the painted specimens are reweighed. To date all of the AS1/3501-6 Task I and II specimens have been measured and weighed. Approximately 1000 specimens have been painted. Weighing, measuring, and painting of the remaining specimens is continuing.

Hexcel's Kevlar 49/F161-188 material system was purchased to Boeing's Material Specification BMS 8-218, "Aramid Fabrics Pre-impregnated With Epoxy Resin (350°F Curing)". This system is qualified to this specification so no exceptions were necessary. The summary of the receiving inspection tests is shown in Table 4-2. All of the values shown meet the specification requirements. The 40 required laminate panels have been fabricated and their integrity verified with the same techniques employed on the other systems. The panels are now being machined into the 3400 required specimens. This task is approximately 80% complete. Measurement of width, thickness, and weight for the Kevlar specimens will begin soon followed by painting of those specimens requiring it.

Kevlar material quantities, laminates, and specimen counts were based on treating this system like Narmco 5208 in the test matrix. This means that complete laboratory characterization will be performed with this material. The AS1/3501-6 graphite system will be tested like Narmco 5209. This was discussed in greater detail in the Seventh Quarterly Progress Report.

Fabrication of flight and ground fixtures, ground rack insert panels, and ground racks is complete except for some work remaining on the stressed tension fixtures.

Table 4-1. AS1/3501-6 Receiving Inspection Data

RECEIVING INSPECTION TEST RESULTS PER BMS 8-212 D

(1)

SUPPLIER AND MATERIAL HERCULES AS1/3501-6

TYPE II CLASS 1 GRADE 145 BATCH/ROLL 1386/2

DATE OF MANUFACTURE 11-7-79 DATE OF RECEIPT 11-21-79

PREPREG PHYSICAL PROPERTIES

PROPERTY	RESULTS — INDIVIDUAL TEST NUMBER					
	1	2	3	4	5	AVERAGE
Areal Weight Graphite Only gm/m^2	145.5	146.1	144.1			145.2
Resin Content, Percent Weight	38.4	38.6	39.2			38.7
Volatiles Content, Percent Weight	0.3	0.3	0.3			0.3
Flow, Percent Weight	22.5	23.5	23.4			23.2
Gel Time, Minutes	(2)					
Tack						PASS

LAMINATE PHYSICAL AND MECHANICAL PROPERTIES

PROPERTY		RESULTS — INDIVIDUAL TEST NUMBER					
		1	2	3	4	5	AVERAGE
Ply Thickness, mils		5.1 (2)	5.3 (2)				5.2
Fiber Volume, percent		65.4 (4)	63.4 (4)				64.4
Void Content							PASS
0° Short Beam Shear Strength, ksi	$-65^{\circ}F$	16.492	19.703	18.660	20.668	21.395	19.383
	RT	15.990	14.396	15.564	15.072	14.521	15.099
	$270^{\circ}F$	9.704	10.463	10.199	9.903	9.796	10.014
0° Tensile Strength, ksi	RT	224.368	209.945	260.977	221.814	227.259	228.873
0° Tensile Modulus, msi	RT	21.207	19.847	23.227	21.406	22.315	21.581
$\pm 45^{\circ}$ Tensile Strength	$-65^{\circ}F$	(2)					
	RT	(2)					

NOTES

(1) Specification Modified Slightly for Non Qualified System
(2) This Test No Longer Required for Receiving Inspection
(3) Average of 10 Readings
(4) Average of 3 Readings

Table 4-2. Kevlar 49/F161-188 Receiving Inspection Data

RECEIVING INSPECTION TEST RESULTS PER BMS 8-213

SUPPLIER AND MATERIAL HEXCEL KEVLAR 49/F161-188
STYLE 1.0 BATCH/ROLL 55154/1
DATE OF MANUFACTURE 2-1-80 DATE OF RECEIPT 2-13-80

PREPREG PHYSICAL PROPERTIES

PROPERTY	RESULTS					AVERAGE
	INDIVIDUAL TEST NUMBER					
	1	2	3	4	5	
Resin Content, Percent Weight	56.99	55.62	57.88	-	-	56.83
Volatiles Content, Percent Weight	0.417	0.466	0.450	-	-	0.444
Flow, Percent Weight	28.40	29.11	22.26	-	-	26.59
Gel Time, Minutes	4:30	3:30	3:58	-	-	3:59

LAMINATE PHYSICAL AND MECHANICAL PROPERTIES

PROPERTY	RESULTS					AVERAGE
	INDIVIDUAL TEST NUMBER					
	1	2	3	4	5	
Ply Thickness, mils	4.20	4.35	4.30	4.33	4.35	4.30
0° Tensile Strength, ksi RT	50.0	50.5	51.6	51.7	49.8	50.75
0° Tensile Modulus, msi RT	3.45	3.14	3.37	2.93	3.29	3.24
0° Compressive Strength, ksi RT	27.5	27.9	26.8	24.1	24.8	26.2

NOTES

5.0 TEST

Progress in the area of test during this reporting period was highlighted by the initial Task I and Task II post exposure residual strength tests. Some additional Task III post exposure tests took place and exposures for all three tasks are continuing.

5.1 LONG TERM EXPOSURE AND TESTS

All of the initial long term specimens have now been deployed. In addition, nominal one year specimens were withdrawn from NASA Dryden Flight Research Center, Honolulu, and Aloha Airlines. A summary of the long term specimen exposure data is shown in Table 5-1. Receipt of the nominal one year specimen from Wellington and Air New Zealand is expected shortly.

The nominal one year ground exposure specimens were removed from the rack at Dryden Flight Research Center on February 12, 1980. This resulted in an actual exposure time of 1.19 years. The specimens were initially photographed "as received" on the insert panels, (see Figures 5-1 and 5-2). Individual specimens were then reidentified, removed from the panels or holding fixtures and cleaned. Test specimens as well as all exposure hardware were in good condition. All of the pieces had a fairly heavy dust film but none had suffered significant paint damage by sand or U.V. degradation. Cleaning was accomplished primarily with a dry cloth. Occasionally, a rag dampened with MEK was employed. The shear exposure, flexure and tension specimens were then weighed on a Sartorius balance to an accuracy of $\pm$.85 mg. After weighing, the tension, compression and flexure specimens were submitted directly to test. Shear exposure specimens were sent to the shop to be machined into short beam shear specimens. After machining, these specimens were also sent to test.

Physical and mechanical property test results are shown in Table 5-2 for the solar specimens and Table 5-3 for the non-solar specimens. Normally, values shown represent a single specimen. The one exception is the failure load for all shear exposure (SE) specimens. In this case, the value shown represents the average of three specimens. The three specimens were exposed as a single piece of graphite, but machined into thirds immediately prior to test as explained above. A summary of all the one year, Dryden, solar exposure is shown in Table 5-4. Comparable non-solar data is shown in Table 5-5.

Specimens were removed from the Honolulu ground rack on 3-14-80 resulting in an actual exposure time of 1.09 years. These specimens were treated like the Dryden specimens when they arrived in Seattle. Specimens and exposure fixtures were in good condition.

Physical and mechanical property test results are shown in Table 5-6 for the solar specimens and Table 5-7 for the non-solar specimens. The summary of the nominal one year Honolulu data is shown in Tables 5-8 and 5-9.

Specimens were also removed from Aloha aircraft N73721 on 3-14-80, again resulting in an actual exposure time of 1.09 years. The aircraft specimens and fixtures were in good condition. The exterior aircraft specimens were dirtier than any of the specimens removed to date. The MEK dampened rag was effective in cleaning these specimens. Individual specimen results for exterior aircraft solar and non-solar exposure are shown in Tables 5-10 and 5-11, respectively. Comparable interior data is shown in Table 5-12. Summary data for the three aircraft exposure locations is shown in Tables 5-13, 5-14, and 5-15.

Table 5-1. Long Term Specimen Exposure Data

SERIES NAME	INSTALLATION DATE	ESTIMATED EXPOSURE AS OF AUGUST 31, 1980 [3]		
		CALENDAR TIME (DAYS)	FLIGHT HOURS	FLIGHT CYCLES
TASK I				
Aloha - 3 Year	3-14-80	170	825	2450
Aloha - 2 Year	2-14-79	564	2844	8918
Aloha - 10 Year	2-16-79	562	2146	5843
ANZ - 1 Year	6-28-79	430	2573	3510
ANZ - 2 Year	8-15-79	382	2226	3058
ANZ - 10 Year	7-2-79	426	2430	3395
Southwest - 1 Year	2-15-80	198	1893	2421
Southwest - 2 Year	2-27-80 [1]	186	1774	2371
Southwest - 10 Year	6-22-80	70	TBD	TBD
TASK II				
NASA Dryden	12-6-78 [2]	574		
Honolulu	2-9-79	508		
Wellington	7-4-79	364		
Dallas	4-18-80	135		

[1] Median date for installation of exterior and interior specimens.

[2] Rack Stored in Unheated Warehouse at Hugh L. Dryden Flight Research Center from 10-30-79 to Date of Installation.

[3] Flight data based on Actuals through June 30, 1980 and Historial Utilization Data.

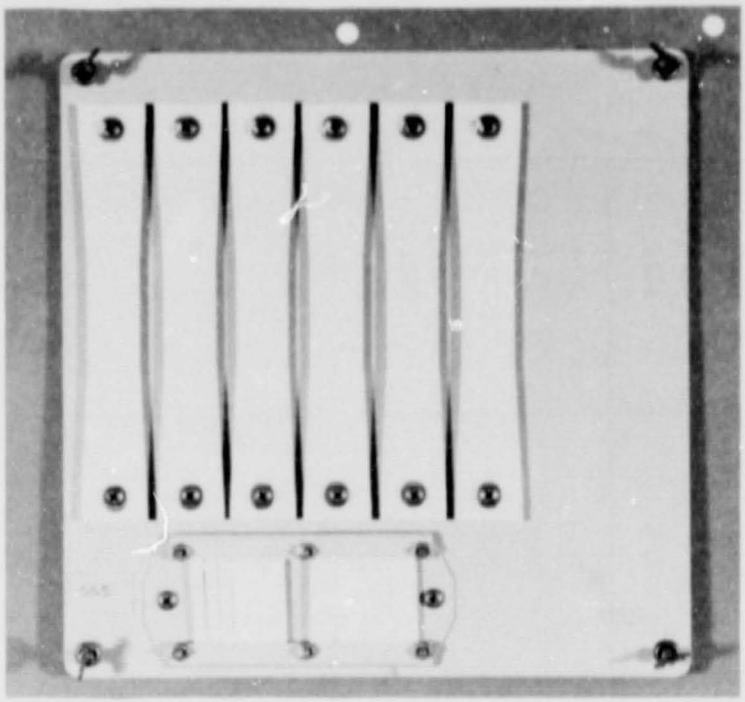


Figure 5-1. Dryden 1 Year Ground Exposure Panel, Solar

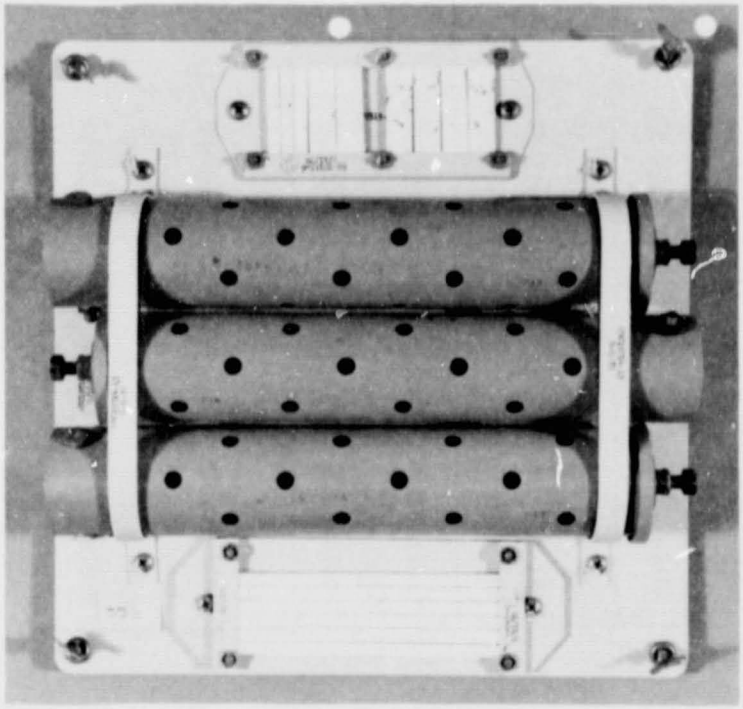


Figure 5-2. Dryden 1 Year Ground Exposure Panel, Non-Solar

Table 5-2. Physical and Mechanical Test Results, Dryden 1 Year Solar Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
ASEESd1-1	0.4935	0.2445	1.3207	1.4974	1.4973		533.70	70.0
ASEESd1-2	0.4961	0.2546	1.3131	1.4778	1.4790		390.30	180.0
ASEESd1-3	0.4959	0.2501	1.3204	1.4919	1.4931	1.4919	454.20	180.0
AFEESd1-1	0.4972	0.4936	1.7451	2.0229	2.0203		141.50	70.0
AFEESd1-2	0.4981	0.4978	1.7444	2.0254	2.0202		143.50	70.0
AFEESd1-3	0.4982	0.4984	1.7695	2.0444	2.0399		136.50	70.0
AFEESd1-4	0.4988	0.4980	1.7587	2.0263	2.0226		149.00	180.0
AFEESd1-5	0.4958	0.4980	1.7417	2.0171	2.0143		128.00	180.0
AFEESd1-6	0.4975	0.4979	1.7997	2.0582	2.0565		139.00	180.0
A14ESd1-1	0.4931	1.0022	9.0346	10.0003	10.7934		1030.00	70.0
A14ESd1-2	0.4926	1.0012	9.0304	10.0457	10.0346		1030.00	70.0
A14ESd1-3	0.4926	1.0020	9.0031	10.0580	10.0494		1030.00	70.0
AT4ESd1-4	0.4924	1.0016	8.9023	10.7265	10.7164		810.00	180.0
AT4ESd1-5	0.4925	1.0009	8.9557	10.7154	10.7081		800.00	180.0
A14ESd1-6	0.4927	1.0035	9.0710	10.8588	10.8535		770.00	180.0
BSEESd1-1	0.1928	0.2497	1.3988	1.5485	1.5485		300.70	70.0
BSEESd1-2	0.1923	0.2488	1.3746	1.5444	1.5458		247.30	180.0
BSEESd1-3	0.1924	0.2492	1.3904	1.5395	1.5400	1.5323	290.80	180.0
BFEESd1-1	0.4928	0.4900	1.6595	1.9499	1.9443		125.50	70.0
BFEESd1-2	0.4935	0.4895	1.6519	1.9344	1.9299		120.50	70.0
BFEESd1-3	0.4934	0.4988	1.6846	1.9690	1.9641		151.50	70.0
BFEESd1-4	0.4925	0.4962	1.6667	1.9564	1.9525		102.50	180.0
BFEESd1-5	0.4936	0.4935	1.6582	1.9316	1.9271		115.50	180.0
BFEESd1-6	0.4932	0.4956	1.6605	1.9491	1.9438		99.50	180.0
B14ESd1-1	0.4948	1.0018	9.5704	11.4339	11.4214		1300.00	70.0
B14ESd1-2	0.4956	1.0025	9.5169	11.2866	11.2764		1200.00	70.0
BT4ESd1-3	0.4955	1.0025	9.5578	11.4056	11.3925		1270.00	70.0
BT4ESd1-4	0.4957	1.0010	9.5477	11.3344	11.3225		1095.00	180.0
BT4ESd1-5	0.4957	1.0040	9.5606	11.3690	11.3721		1040.00	180.0
B14ESd1-6	0.4976	1.0012	9.7782	11.5449	11.5318		1110.00	180.0

Table 5-2. Physical and Mechanical Test Results, Dryden 1 Year Solar Specimens (Concluded)

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
CSEESd1-1	0.1bs0	0.2491	1.4854	1.6531	1.6549		514.70	70.0
CSEESd1-2	0.1d91	0.2457	1.4717	1.6252	1.6265		356.70	180.0
CSEESd1-3	0.11u6	0.2469	1.5144	1.6438	1.6454	1.6340	417.20	180.0
CFLESd1-1	0.1b82	0.4993	1.8231	2.0827	2.0810		160.00	70.0
CFLESd1-2	0.1b71	0.4984	1.8063	2.0668	2.0659		160.00	70.0
CFLESd1-3	0.1b78	0.4993	1.8245	2.0851	2.0831		167.00	70.0
CFLESd1-4	0.1be3	0.4975	1.8318	2.0829	2.0810		134.00	180.0
CFLESd1-5	0.1b66	0.4993	1.7750	2.0395	2.0365		144.50	180.0
CFLESd1-6	0.1bb0	0.4981	1.7797	2.0439	2.0410		149.50	180.0
CT4ESd1-1	0.1470	1.0031	9.7748	11.7165	11.7110		1120.00	70.0
CT4ESd1-2	0.1469	1.0013	9.6940	11.0021	11.0040		1140.00	70.0
CT4ESd1-3	0.1454	1.0004	9.8164	11.7272	11.7230		1135.00	70.0
CT4ESd1-4	0.1461	1.0027	9.8914	11.8664	11.8593		1010.00	180.0
CT4ESd1-5	0.1467	1.0026	9.8440	11.8521	11.8419		1070.00	180.0
CT4ESd1-6	0.1471	1.0011	9.8309	11.8228	11.8113		1030.00	180.0

Table 5-3. Physical and Mechanical Test Results, Dryden 1 Year Non Solar Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
ASEE001 -1	0.0962	0.2499	1.3216	1.4984	1.4994		499.30	70.0
ASEE001 -2	0.0972	0.2497	1.3344	1.5098	1.5113		403.70	100.0
ASEE001 -3	0.0964	0.2493	1.3504	1.5250	1.5268	1.5146	420.30	100.0
AFLE001 -1	0.0609	0.4974	1.7666	2.0479	2.0490		145.00	70.0
AFLE001 -2	0.0602	0.4964	1.7532	2.0451	2.0442		144.00	70.0
AFLE001 -3	0.0675	0.4999	1.7630	2.0494	2.0496		159.00	70.0
AFLE001 -4	0.0601	0.4943	1.7463	2.0450	2.0443		144.50	100.0
AFLE001 -5	0.0602	0.5000	1.7767	2.0827	2.0819		144.00	100.0
AFLE001 -6	0.0653	0.4936	1.7513	2.0535	2.0519		141.50	100.0
AI4E001 -1	0.0460	1.0020		25.4321	25.4445		980.00	100.0
AI4E001 -2	0.0459	1.0036		26.0456	26.0579		910.00	100.0
AI4E001 -3	0.0460	0.9945		25.3508	25.3652		940.00	100.0
ACOE001 -1	0.1004	0.2413					6140.00	70.0
ACOE001 -2	0.1053	0.2442					6192.00	70.0
ACOE001 -3	0.1016	0.2473					6020.00	70.0
ACOE001 -4	0.1042	0.2460					3170.00	100.0
ACOE001 -5	0.1030	0.2429					3630.00	100.0
ACOE001 -6	0.1031	0.2472					3550.00	100.0
BSEE001 -1	0.1031	0.2450	1.3559	1.5384	1.5389		400.00	70.0
BSEE001 -2	0.1024	0.2440	1.3792	1.5515	1.5529		253.30	100.0
BSEE001 -3	0.1022	0.2516	1.4116	1.5847	1.5858	1.5755	272.20	100.0
BFLE001 -1	0.0636	0.4956	1.6754	1.9529	1.9516		146.00	70.0
BFLE001 -2	0.0655	0.4921	1.6532	1.9814	1.9788		136.00	70.0
BFLE001 -3	0.0642	0.4921	1.6566	1.9743	1.9709		137.50	70.0
BFLE001 -4	0.0628	0.4995	1.6652	1.9823	1.9788		76.50	100.0
BFLE001 -5	0.0635	0.4975	1.6626	1.9553	1.9530		120.00	100.0
BFLE001 -6	0.0634	0.4938	1.6610	1.9606	1.9582		112.00	100.0
BI4E001 -1	0.0437	1.0010		25.3019	25.2860		1065.00	100.0
BI4E001 -2	0.0436	1.0040		25.5542	25.5341		1055.00	100.0
BI4E001 -3	0.0433	1.0046		25.4677	25.4513		970.00	100.0
BCOE001 -1	0.1010	0.2442					7010.00	70.0
BCOE001 -2	0.1011	0.2493					6300.00	70.0
BCOE001 -3	0.1020	0.2494					5750.00	70.0
BCOE001 -4	0.1030	0.2499					5500.00	100.0
BCOE001 -5	0.1019	0.2497					5020.00	100.0
BCOE001 -6	0.1030	0.2491					5200.00	100.0

Table 5-3. Physical and Mechanical Test Results, Dryden 1 Year Non Solar Specimens (Concluded)

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
CSEENW1-1	0.1162	0.2483	1.4935	1.6477	1.6494		516.30	70.0
CSEENW1-2	0.1176	0.2454	1.4517	1.6058	1.6077		343.30	180.0
CSEENW1-3	0.1111	0.2475	1.5086	1.6693	1.6692	1.6572	486.00	180.0
CFLENW1-1	0.0677	0.4978	1.7904	2.0572	2.0568		157.50	70.0
CFLENW1-2	0.0657	0.4993	1.7587	2.0278	2.0254		139.50	70.0
CFLENW1-3	0.0674	0.4978	1.7987	2.0652	2.0641		154.20	70.0
CFLENW1-4	0.0665	0.5019	1.8010	2.0754	2.0750		145.50	180.0
CFLENW1-5	0.0667	0.5005	1.7874	2.0722	2.0709		149.00	180.0
CFLENW1-6	0.0673	0.4983	1.7753	2.0628	2.0609		155.00	180.0
CI4ENW1-1	0.0967	1.0028		26.4954	26.4990		1175.00	180.0
CI4ENW1-2	0.1403	0.9997		26.2646	26.2851		1130.00	180.0
CI4ENW1-3	0.0697	1.0025		26.6798	26.6904		1120.00	180.0
CCYENW1-1	0.1055	0.2534					6850.00	70.0
CCYENW1-2	0.1950	0.2512					6600.00	70.0
CCYENW1-3	0.1968	0.2518					6140.00	70.0
CCYENW1-4	0.1051	0.2520					3670.00	180.0
CCYENW1-5	0.1055	0.2524					3660.00	180.0
CCYENW1-6	0.1051	0.2506					3649.00	180.0

*Table 5-4. Results Summary, Dryden Nominal 1 Year Solar Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM 5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	111.5	84.1	93.2
	Flexure	99.3	104.6	104.5
	Tension	104.6	110.4	104.8
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	98.5	79.1	79.8
	Flexure	106.1	98.8	102.5
	Tension	95.8	90.6	95.9
	SBS Dryout	115.2	92.7	90.8
Weight Change Data Percent Gain + Percent Loss -	SBS	0.0517	0.0238	0.112
	Flexure	-0.166	-0.245	-0.101
	Tension	-0.0761	-0.1136	-0.0499
	SBS During Dryout	-0.670	-0.682	-0.468
OTHER				

Notes:

* These specimens exposed for 433 days.

** Residual strength data based on baseline tests at the respective temperatures

*Table 5-5. Results Summary, Dryden Nominal 1 Year Non-Solar Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	99.2	89.5	97.0
	Flexure	105.4	106.5	99.8
	Compression			
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	101.4	82.2	77.8
	Flexure	112.8	107.0†	107.5
	Compression			
	Stressed Tension			
	SBS Dryout	104.2	86.2	88.9
Weight Change Data Percent Gain + Percent Loss -	SBS	0.0947	0.0641	0.0718
	Flexure	-0.0219	-0.1295	-0.0545
	Stressed Tension	0.121	0.153	0.0547
	SBS During Dryout	-0.581	-0.548	-0.725
OTHER				
†Measurement outside 1 standard deviation thrown out.				

Notes:

* These specimens exposed for 433 days.

** Residual strength data based on baseline tests at the respective temperatures

Table 5-6. Physical and Mechanical Test Results, Honolulu 1 Year Solar Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
A5EnSc1-1	[illegible]	[illegible]	1.3254	1.4724	1.47e3		449.00	75.0
A5EnSc1-2	[illegible]	[illegible]	1.4096	1.5592	1.5e35		376.70	100.0
A5EnSc1-3	[illegible]	[illegible]	1.3151	1.45e4	1.4565	1.4410	477 [illegible]	75.0
AFLnSc1-1	[illegible]	[illegible]	1.7575	2.0765	2.0793		136. [illegible]	75.0
AFLnSc1-2	[illegible]	[illegible]	1.7344	2.0429	2.0455		134.00	75.0
AFLnSc1-3	[illegible]	[illegible]	1.7797	2.0611	2.0743		150.50	75.0
AFLnSc1-4	[illegible]	[illegible]	1.7732	2.0514	2.0542		146.00	100.0
AFLnSc1-5	[illegible]	[illegible]	1.7219	1.9918	1.9944		149.50	100.0
AFLnSc1-6	[illegible]	[illegible]	1.7691	2.0616	2.0853		134.00	100.0
AT4nSc1-1	[illegible]	[illegible]	9.0831	10.8741	10.8797		1000.00	75.0
AT4nSc1-2	[illegible]	[illegible]	8.9703	10.7873	10.7925		1050.00	75.0
AT4nSc1-3	[illegible]	[illegible]	8.9864	10.8860	10.8899		1050.00	75.0
AT4nSc1-4	[illegible]	[illegible]	9.0309	10.7998	10.8026		800.00	100.0
AT4nSc1-5	[illegible]	[illegible]	8.9868	10.7776	10.7836		830.00	100.0
AT4nSc1-6	[illegible]	[illegible]	9.0074	10.7456	10.7542		800.00	100.0
b5EnSc1-1	[illegible]	[illegible]	1.3466	1.52e3	1.5203		304.00	75.0
b5EnSc1-2	[illegible]	[illegible]	1.4075	1.6090	1.6061		234.00	100.0
b5EnSc1-3	[illegible]	[illegible]	1.3956	1.5747	1.5746	1.5649	532.30	75.0
bFLnSc1-1	[illegible]	[illegible]	1.6791	1.9426	1.9411		122.00	75.0
bFLnSc1-2	[illegible]	[illegible]	1.7011	1.9520	1.9505		131.00	75.0
bFLnSc1-3	[illegible]	[illegible]	1.6598	1.9124	1.9109		135.00	75.0
bFLnSc1-4	[illegible]	[illegible]	1.6754	1.9327	1.9315		100.50	100.0
bFLnSc1-5	[illegible]	[illegible]	1.6650	1.9260	1.9186		86.50	100.0
bFLnSc1-6	[illegible]	[illegible]	1.6556	1.9131	1.9113		90.50	100.0
b14nSc1-1	[illegible]	[illegible]	9.3472	10.9717	10.9820		1200.00	75.0
b14nSc1-2	[illegible]	[illegible]	9.2447	11.1900	11.1095		1153.00	75.0
b14nSc1-3	[illegible]	[illegible]	9.3429	10.9454	10.9594		1150.00	75.0
b14nSc1-4	[illegible]	[illegible]	9.1495	11.0219	11.0280		800.00	100.0
b14nSc1-5	[illegible]	[illegible]	9.2460	11.1753	11.1766		960.00	100.0
b14nSc1-6	[illegible]	[illegible]	9.2825	10.8836	10.8900		960.00	100.0

Table 5-6. Physical and Mechanical Test Results, Honolulu 1 Year Solar Specimens(Concluded)

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
C6Enn61 -1	[illegible]	[illegible]	1.4821	1.9445	1.6495		486.00	75.0
C6Enn61 -2	[illegible]	[illegible]	1.5155	1.6918	1.6958		341.70	100.0
C6En561 -3	[illegible]	[illegible]	1.5242	1.7075	1.7125	1.6973	500.00	75.0
C6Enn61 -1	[illegible]	[illegible]	1.7569	2.0393	2.0432		140.00	75.0
C6Enn61 -2	[illegible]	[illegible]	1.7319	2.0074	2.0106		139.00	75.0
C6Enn61 -3	[illegible]	[illegible]	1.7877	2.0900	2.0935		152.00	75.0
C6Enn61 -4	[illegible]	[illegible]	1.7965	2.0040	2.0078		141.00	100.0
C6En561 -5	[illegible]	[illegible]	1.6094	2.1044	2.1083		145.50	100.0
C6Enn61 -6	[illegible]	[illegible]	1.8012	2.0772	2.0810		143.50	100.0
C14n561 -1	[illegible]	[illegible]	9.6206	11.5015	11.5227		1125.00	75.0
C14n561 -2	[illegible]	[illegible]	9.9182	11.6584	11.6788		1113.00	75.0
C14n561 -3	[illegible]	[illegible]	9.8821	11.7400	11.7589		1066.00	75.0
C14n561 -4	[illegible]	[illegible]	9.9354	11.8193	11.8346		1230.00	100.0
C14n561 -5	[illegible]	[illegible]	9.9242	11.7383	11.7579		1010.00	100.0
C14n561 -6	[illegible]	[illegible]	9.9099	11.7479	11.7670		1025.00	100.0

Table 5-7. Physical and Mechanical Test Results, Honolulu 1 Year Non-Solar Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
ASEM-01 -1	[illegible]	0.2493	1.3039	1.4609	1.4662		469.30	75.0
ASEM-01 -2	[illegible]	0.2449	1.3249	1.4590	1.4624		335.70	180.0
ASEM-01 -3	[illegible]	0.2519	1.3749	1.5429	1.5469	1.5337	447.30	75.0
AFLM-01 -1	[illegible]	[illegible]	1.7575	2.0565	2.0612		147.00	75.0
AFLM-01 -2	[illegible]	[illegible]	1.7600	2.0912	2.0951		143.00	75.0
AFLM-01 -3	[illegible]	[illegible]	1.7004	2.0570	2.0615		155.50	75.0
AFLM-01 -4	[illegible]	[illegible]	1.7940	2.1256	2.1323		165.50	180.0
AFLM-01 -5	[illegible]	[illegible]	1.7878	2.0667	2.0726		146.50	180.0
AFLM-01 -6	[illegible]	[illegible]	1.7699	2.0463	2.0520		140.00	180.0
AI4M-01 -1	[illegible]	0.9956		25.7932	25.8263		1385.00	180.0
AI4M-01 -2	[illegible]	[illegible]		26.0190	26.0530		990.00	180.0
AI4M-01 -3	[illegible]	[illegible]		26.0078	26.0412		1040.00	180.0
BSEM-01 -1	[illegible]	0.2447	1.3026	1.5225	1.5245		371.30	75.0
BSEM-01 -2	[illegible]	0.2514	1.4215	1.5930	1.5941		233.70	180.0
BSEM-01 -3	[illegible]	0.2463	1.3724	1.5299	1.5315	1.5226	491.30	75.0
BFLM-01 -1	[illegible]	0.4940	1.8491	1.8985	1.8990		123.50	75.0
BFLM-01 -2	[illegible]	0.4988	1.8655	1.9365	1.9351		135.50	75.0
BFLM-01 -3	[illegible]	0.4926	1.8566	1.9230	1.9230		142.50	75.0
BFLM-01 -4	[illegible]	0.4991	1.8825	1.9557	1.9554		99.00	180.0
BFLM-01 -5	[illegible]	0.4973	1.8753	1.9430	1.9422		97.50	180.0
BFLM-01 -6	[illegible]	0.4958	1.8692	1.9203	1.9210		110.00	180.0
B14M-01 -1	[illegible]	1.0039		25.3865	25.3960			180.0
B14M-01 -2	[illegible]	1.0054		25.3476	25.3593		925.00	180.0
B14M-01 -3	[illegible]	1.0031		25.2238	25.2331		920.00	180.0
CSEM-01 -1	[illegible]	0.2476	1.4857	1.6713	1.6763		452.00	75.0
CSEM-01 -2	[illegible]	0.2463	1.5252	1.7073	1.7127		340.00	180.0
CSEM-01 -3	[illegible]	0.2564	1.5030	1.6946	1.7004	1.6841	576.00	75.0
CFLM-01 -1	[illegible]	0.4927	1.7362	2.0043	2.0086		157.00	75.0
CFLM-01 -2	[illegible]	0.4963	1.7961	2.1027	2.1071		160.00	75.0
CFLM-01 -3	[illegible]	0.4992	1.8096	2.0975	2.1022		161.00	75.0
CFLM-01 -4	[illegible]	0.5062	1.8227	2.1089	2.1136		146.50	180.0
CFLM-01 -5	[illegible]	0.4976	1.7985	2.0794	2.0841		142.00	180.0
CFLM-01 -6	[illegible]	0.4960	1.7523	2.0382	2.0428		131.50	180.0
CI4M-01 -1	[illegible]	1.0025		26.1842	26.2215		1075.00	180.0
CI4M-01 -2	[illegible]	1.0027		26.3992	26.4388		1170.00	180.0
CI4M-01 -3	[illegible]	1.0031		26.2894	26.2463		1165.00	180.0

*Table 5-8. Results Summary, Honolulu Nominal 1 Year Solar Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM 5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	89.4	82.4	87.0
	Flexure	102.7	101.7	105.6
	Tension	107.5	104.9	103.5
	SBS Dryout	95.5	117.0	100.5
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	87.5	74.6	73.4
	Flexure	111.1	89.4	103.2
	Tension	98.2	80.8	94.0
Weight Change Data Percent Gain + Percent Loss -	SBS	0.270	-0.0280	0.294
	Flexure	0.0634	-0.0769	0.1781
	Tension	0.0455	0.0734	0.1624
	SBS During Dryout	-0.985	-0.620	-0.896
OTHER				

Notes:

* These specimens exposed for 398 days.

** Residual strength data based on baseline tests at the respective temperatures

*Table 5-9. Results Summary, Honolulu Nominal 1 Year Non-Solar Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM 5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	95.0	83.7	80.4
	Flexure	108.2	107.7	106.6
	Compression			
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	85.1	73.4	72.9
	Flexure	111.0	95.8	102.1
	Compression			
	Stressed Tension	112.5	80.37†	106.1
Weight Change Data Percent Gain + Percent Loss -	SBS	0.296	0.0673	0.306
	Flexure	-0.0139	-0.0110	0.218
	Stressed Tension	0.310	0.0876	0.324
	SBS During Dryout	-0.861	0.585	-0.968
OTHER				

† Average of two measurements

Notes:

* These specimens exposed for 398 days.

** Residual strength data based on baseline tests at the respective temperatures

Table 5-10. Physical and Mechanical Test Results, Aloha Airlines, 1 Year Solar Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
[illegible]	[illegible]	0.2501	1.3405	1.5062	1.5124		440.30	75.0
[illegible]	[illegible]	0.2490	1.2934	1.4610	1.4669		344.30	180.0
[illegible]	[illegible]	[illegible]	1.3221	1.4805	1.4862	1.4717	412.00	180.0
[illegible]	[illegible]	[illegible]	1.7507	2.0084	2.0162		145.00	75.0
[illegible]	[illegible]	[illegible]	1.7019	2.0065	2.0153		147.50	75.0
[illegible]	[illegible]	[illegible]	1.7750	2.0335	2.0422		151.00	75.0
[illegible]	[illegible]	[illegible]	1.7644	2.0279	2.0353		149.00	180.0
[illegible]	[illegible]	[illegible]	1.7774	2.0503	2.0583		140.50	180.0
[illegible]	[illegible]	[illegible]	1.7750	2.0560	2.0672		146.00	180.0
[illegible]	[illegible]	0.9960	9.7144	11.9400	11.9372		1140.00	180.0
[illegible]	[illegible]	1.0029	9.8579	11.8278	11.8247		1100.00	180.0
[illegible]	[illegible]	0.2509	1.3552	1.5355	1.5402		374.30	75.0
[illegible]	[illegible]	0.2453	1.3517	1.5150	1.5188		222.70	180.0
[illegible]	[illegible]	0.2453	1.3886	1.5541	1.5569	1.5439	308.30	180.0
[illegible]	[illegible]	0.4935	1.8680	1.9669	1.9681		140.00	75.0
[illegible]	[illegible]	0.4938	1.6735	1.9571	1.9594		138.50	75.0
[illegible]	[illegible]	0.4888	1.6497	1.9277	1.9300		142.50	75.0
[illegible]	[illegible]	0.4933	1.6684	1.9247	1.9267		99.00	180.0
[illegible]	[illegible]	0.4941	1.6629	1.9334	1.9346		102.00	180.0
[illegible]	[illegible]	0.4968	1.6713	1.9312	1.9332		86.50	180.0
[illegible]	[illegible]	0.2488	1.4957	1.6695	1.6777		474.70	75.0
[illegible]	[illegible]	0.2499	1.4687	1.6278	1.6361		344.30	180.0
[illegible]	[illegible]	0.2486	1.4566	1.6644	1.6129	1.5952	411.70	180.0
[illegible]	[illegible]	0.5019	1.6157	2.1048	2.1137		161.00	75.0
[illegible]	[illegible]	0.5024	1.7979	2.0763	2.0857		159.00	75.0
[illegible]	[illegible]	0.5001	1.8302	2.1247	2.1332		165.50	75.0
[illegible]	[illegible]	0.4992	1.7490	2.0488	2.0549		140.50	180.0
[illegible]	[illegible]	0.5001	1.7497	2.0486	2.0563		130.00	180.0
[illegible]	[illegible]	0.5007	1.8265	2.1069	2.1176		149.50	180.0
[illegible]	[illegible]	1.0049	9.9097	11.9793	11.9782		1130.00	180.0
[illegible]	[illegible]	1.0031	9.8141	11.7871	11.7913		1215.00	180.0

Table 5-11. Physical and Mechanical Test Results, Aloha Airlines 1 Year Non-Solar Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
[illegible]	[illegible]	[illegible]	1.3562	1.5031	1.5092		457.70	75.0
ASEA**1-2	[illegible]	[illegible]	1.2670	1.4285	1.4350		325.30	180.0
ASEA**1-3	[illegible]	[illegible]	1.3299	1.4704	1.4750	1.4612	395.70	180.0
[illegible]	[illegible]	[illegible]	1.7092	2.0783	2.0845		151.00	75.0
[illegible]	[illegible]	[illegible]	1.7741	2.0698	2.0742		149.50	75.0
[illegible]	[illegible]	[illegible]	1.7632	2.0455	2.0508		177.00	75.0
[illegible]	[illegible]	[illegible]	1.7397	2.0273	2.0325		131.00	180.0
[illegible]	[illegible]	[illegible]	1.7047	2.0370	2.0440		142.00	180.0
[illegible]	[illegible]	[illegible]	1.7002	2.0522	2.0585		146.50	180.0
[illegible]	[illegible]	[illegible]	9.0517	11.5569	11.5659		998.00	180.0
[illegible]	[illegible]	[illegible]	9.0480	11.5369	11.5479		1060.00	180.0
DSEA**1-1	[illegible]	[illegible]	1.3856	1.5403	1.5434		305.00	75.0
DSEA**1-2	[illegible]	[illegible]	1.4006	1.5593	1.5634		231.00	180.0
DSEA**1-3	[illegible]	[illegible]	1.3922	1.5469	1.5504	1.5396	299.00	180.0
[illegible]	[illegible]	[illegible]	1.6061	1.9115	1.9138		122.00	75.0
[illegible]	[illegible]	[illegible]	1.6746	1.9330	1.9351		148.50	75.0
[illegible]	[illegible]	[illegible]	1.6709	1.9485	1.9507		122.00	75.0
[illegible]	[illegible]	[illegible]	1.6525	1.9094	1.9118		97.50	180.0
[illegible]	[illegible]	[illegible]	1.6873	1.9525	1.9562		100.00	180.0
[illegible]	[illegible]	[illegible]	1.6664	1.9328	1.9362		88.50	180.0
CSEA**1-1	[illegible]	[illegible]	1.5256	1.7022	1.6869		475.00	75.0
CSEA**1-2	[illegible]	[illegible]	1.5073	1.6750	1.6823		337.00	180.0
CSEA**1-3	[illegible]	[illegible]	1.5228	1.6799	1.7104	1.6918	430.30	180.0
CFEA**1-1	[illegible]	[illegible]	1.7916	2.0032	2.0704		159.00	75.0
CFEA**1-2	[illegible]	[illegible]	1.7972	2.0590	2.0665		161.00	75.0
CFEA**1-3	[illegible]	[illegible]	1.7795	2.0767	2.0838		149.50	75.0
CFEA**1-4	[illegible]	[illegible]	1.7691	2.0577	2.0638		135.00	180.0
CFEA**1-5	[illegible]	[illegible]	1.7653	2.0662	2.0720		136.50	180.0
CFEA**1-6	[illegible]	[illegible]	1.7412	2.0481	2.0544		132.50	180.0
CI4A**1-1	[illegible]	1.0021	9.8987	11.8767	11.8904		1110.00	180.0
CI4A**1-2	[illegible]	1.0033	9.9175	11.8199	11.8430		1200.00	180.0

Table 5-12. Physical and Mechanical Test Results, Aloha Airlines 1 Year Interior Specimens

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
[illegible] -1	[illegible]	[illegible]	1.3336	1.5078	1.5100		431.00	75.0
[illegible] -2	[illegible]	[illegible]	1.2961	1.4721	1.4746		347.30	180.0
[illegible] -1	[illegible]	[illegible]	1.7619	2.0464	2.0487		145.50	75.0
[illegible] -2	[illegible]	[illegible]	1.7643	2.0377	2.0410		148.00	75.0
[illegible] -3	[illegible]	[illegible]	1.7524	2.0283	2.0200		146.00	75.0
[illegible] -4	[illegible]	[illegible]	1.7493	2.0173	2.0200		146.00	180.0
[illegible] -5	[illegible]	[illegible]	1.7637	2.0336	2.0334		149.00	180.0
[illegible] -6	[illegible]	[illegible]	1.7653	2.0359	2.0383		136.00	180.0
[illegible] -1	[illegible]	1.0000	9.8666	11.7920	11.7935		1165.00	75.0
[illegible] -2	[illegible]	1.0058	9.7353	11.5959	11.6025		1130.00	75.0
[illegible] -3	[illegible]	1.0035	9.7222	11.5071	11.5130		1150.00	75.0
[illegible] -4	[illegible]	[illegible]	9.8668	11.4332	11.4414		965.00	180.0
[illegible] -5	[illegible]	[illegible]	9.8455	11.5576	11.5602		1025.00	180.0
[illegible] -6	[illegible]	[illegible]	9.7424	11.6113	11.6171		1060.00	180.0
[illegible] -7	[illegible]	1.0039		25.6978	25.7290		1020.00	180.0
[illegible] -8	[illegible]	1.0016		25.6996	25.7301		960.00	180.0
[illegible] -9	[illegible]	[illegible]		25.6418	25.6719		975.00	180.0
[illegible] -1	[illegible]	[illegible]	1.3709	1.5342	1.5355		364.00	75.0
[illegible] -2	[illegible]	[illegible]	1.4064	1.5702	1.5710		230.70	180.0
[illegible] -1	[illegible]	[illegible]	1.8552	1.9673	1.9540		142.00	75.0
[illegible] -2	[illegible]	[illegible]	1.8878	1.9974	1.9961		146.00	75.0
[illegible] -3	[illegible]	[illegible]	1.6747	1.9941	1.9907		144.00	75.0
[illegible] -4	[illegible]	[illegible]	1.6900	1.9920	1.9899		107.50	180.0
[illegible] -5	[illegible]	[illegible]	1.6780	1.9845	1.9820		118.50	180.0
[illegible] -6	[illegible]	[illegible]	1.6600	1.9577	1.9600		107.50	180.0
[illegible] -1	[illegible]	1.0018	9.3730	11.6346	11.6072		1225.00	75.0
[illegible] -2	[illegible]	1.0056	9.3612	11.7428	11.7118		1165.00	75.0
[illegible] -3	[illegible]	1.0025	9.2803	11.5267	11.5023		1195.00	75.0
[illegible] -4	[illegible]	1.0046	9.4054	11.7656	11.7364		970.00	180.0
[illegible] -5	[illegible]	1.0041	9.3977	11.5666	11.5443		1115.00	180.0
[illegible] -6	[illegible]	1.0026	9.2799	11.5977	11.5735		955.00	180.0
[illegible] -7	[illegible]	1.0005		25.2500	24.2632		965.00	180.0
[illegible] -8	[illegible]	1.0003		24.9212	24.9296		995.00	180.0
[illegible] -9	[illegible]	1.0007		24.8511	24.8640		1000.00	180.0

Table 5-12. Physical and Mechanical Test Results, Aloha Airlines 1 Year Interior Specimens (Concluded)

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	TEST TEMP. (F)
CSLA1V1-1	0.1495	0.2563	1.5622	1.6602	1.6645		469.70	75.0
CSLA1V1-2	0.1496	0.2488	1.4946	1.6685	1.6722		362.00	180.0
CFLA1V1-1	0.1561	0.5023	1.8302	2.1206	2.1230		170.50	75.0
CFLA1V1-2	0.1569	0.5012	1.8107	2.0973	2.1000		165.50	75.0
CFLA1V1-3	0.1561	0.4996	1.7412	2.0192	2.0201		143.70	75.0
CFLA1V1-4	0.1579	0.5032	1.8408	2.1280	2.1298		145.00	180.0
CFLA1V1-5	0.1576	0.5011	1.8357	2.1042	2.1061		156.00	180.0
CFLA1V1-6	0.1571	0.4967	1.8215	2.0858	2.0845		143.00	180.0
CT4A1V1-1	0.0472	1.0031	9.8514	11.9920	11.9656		1150.00	75.0
CT4A1V1-2	0.0468	1.0031	9.9701	12.1061	12.0838		1065.00	75.0
CT4A1V1-3	0.0469	1.0017	9.9166	12.2287	12.2000		1080.00	75.0
CT4A1V1-4	0.0472	1.0027	9.8894	12.0784	12.0525		1145.00	180.0
CT4A1V1-5	0.0463	1.0006	9.9540	12.0763	12.0562		1025.00	180.0
CT4A1V1-6	0.0456	1.0022	9.7835	11.8869	11.8657		1140.00	180.0
CT4A1V1-7	0.0452	1.0030		25.3820	25.4155		1140.00	180.0
CT4A1V1-8	0.0463	1.0022		26.3439	26.3611		1150.00	180.0
CT4-1V1-9	0.0475	1.0009		26.3924	26.4223		1260.00	180.0

*Table 5-13. Results Summary, Aloha Airlines Nominal 1 Year Solar Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM 5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	87.4	84.6	85.2
	Flexure	106.6	110.3	105.3
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	87.9	72.7	77.4
	Flexure	110.7	87.5	101.8
	Tension	125.5	-----	106.2
	SBS Dryout	104.4	97.4	93.11
Weight Change Data Percent Gain + Percent Loss -	SBS	0.387	0.278	0.500
	Flexure	0.409	0.0946	0.400
	Tension	-0.4843	-----	0.0132
	SBS During Dryout	-0.985	-0.842	-1.110
OTHER				

Notes:

* These specimens exposed for 1942 flight hours, 5760 flight cycles, 394 days on aircraft #N73721.

** Residual strength data based on baseline tests at the respective temperatures

*Table 5-14. Results Summary, Aloha Airlines Nominal 1 Year Non-Solar Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	90.4	80.9	83.3
	Flexure	114.5	100.8	103.4
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	84.1	74.0	73.9
	Flexure	110.1	84.6	99.6
	Tension	106.9	-----	114.4
	SBS Dryout	100.5	94.9	93.1
Weight Change Data Percent Gain + Percent Loss -	SBS	0.430	0.232	-0.2315
	Flexure	0.286	0.139	+0.3169
	Tension	0.0866	-----	0.1554
	SBS During Dryout	-0.944	-0.702	-1.099
OTHER				

Notes:

* These specimens exposed for 1942 flight hours, 5760 flight cycles, 394 days on aircraft #N73721.

** Residual strength data based on baseline tests at the respective temperatures

*Table 5-15. Results Summary, Aloha Airlines Nominal 1 Year Interior Specimens**

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS	84.3	81.4	83.5
	Flexure	107.0	112.4	104.5
	Tension	112.3	107.6	100.4
	Compression			
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS	90.0	76.4	80.0
	Flexure	114.3	102.8	103.6
	Tension	115.6	87.6	103.0
	Compression			
	Stressed Tension	110.4	89.7	109.0
Weight Change Data Percent Gain + Percent Loss -	SBS	0.158	0.0678	0.239
	Flexure	0.0886	-0.171	0.0665
	Tension	0.0442	-0.227	-0.202
	Stressed Tension	0.2810	0.0991	0.2866
OTHER				

Notes:

* These specimens exposed for 1942 flight hours, 5760 flight cycles, 394 days on aircraft #N73721.

** Residual strength data based on baseline tests at the respective temperatures

5.2 LABORATORY EXPOSURE AND TESTING

5.2.1 BASELINE

Some material characterization work was performed on the AS1/3501-6 and Kevlar 49/F161-188 material systems. These results will be included in a subsequent report when the complete characterization is available.

5.2.2 EFFECT OF TIME ALONE

Exposure of specimens to the effects of time alone is continuing. The original plan called for tests after nominally one, three, and ten years of exposure so no tests were scheduled for this time period. Consideration is being given to adding a set of tests at approximately two years of exposure. The results of the nominal one year exposure were described in the Eight Quarterly Progress Report. The changes in strength were small but the specimens were also observed to have lost weight. The weight losses ranged from near zero on one set of specimens to 0.18% for 5208 flexure specimens. It is reasonable to expect that the weight loss was totally due to moisture.

The additional set of specimens would be used to assess the relative influence of time alone and moisture weight change on these specimens. The plan is to test the nominal ten year specimens after approximately two years and package additional specimens from the dry drum storage unit into desiccated jars to replace the ten year specimens. These specimens will have adequate time to stabilize in the jars prior to test.

5.2.3 EFFECT OF MOISTURE AND THE EFFECTS OF TIME AND STRESS ON WET SPECIMENS

Individual test results of 240 short beam shear and flexure specimens exposed to various relative humidities were described in the Eighth Quarterly Progress Report. Significant strength and stiffness changes were observed in some cases. Additional analysis has taken place on these moisture specimens. Table 5-16 shows the observed moisture content in the specimens at the time of the test. Figure 5-3 portrays the same data graphically. All three material systems are shown. It can be seen that, with one exception, the data is relatively consistant at humidities below 75%. It can also be seen that the specimens would show 0% moisture content at around 25% humidity indicating that this was representative of the original, (dry drum storage) environment. Finally, the observed

moisture contents at 95% or condensing humidity are higher than an extrapolation of the lower values would indicate. It is probable that this exposure creates a condition more like water immersion.

Table 5-16. Observed Moisture Content After Humidity Conditioning

SPEC. TYPE OR MATERIAL	RELATIVE HUMIDITY 40%	60%	75%	95%	
ASB	.24%	1.10% [1]	.74%	1.34%	
	.28%	.57%	.81%	1.32%	
AFL	.21%	.58%	.82%	1.44%	
5208 AVG	.24%	.57%	.79%	1.37%	
BSB	.30%	.50%	.78%	-----	[2]
	.33%	.63%	.92%	-----	
BFL	.34%	.57%	.84%	1.84%	
5209 AVG	.32%	.57%	.85%	1.84%	
CSB	.25%	.56%	.85%	1.59%	
	.33%	.65%	.95%	1.71%	
CFL	.22%	.53%	.80%	1.45%	
934 AVG	.27%	.58%	.87%	1.58%	

[1] Obviously erroneous value -- ignore

[2] Never weighed -- re-exposure in work

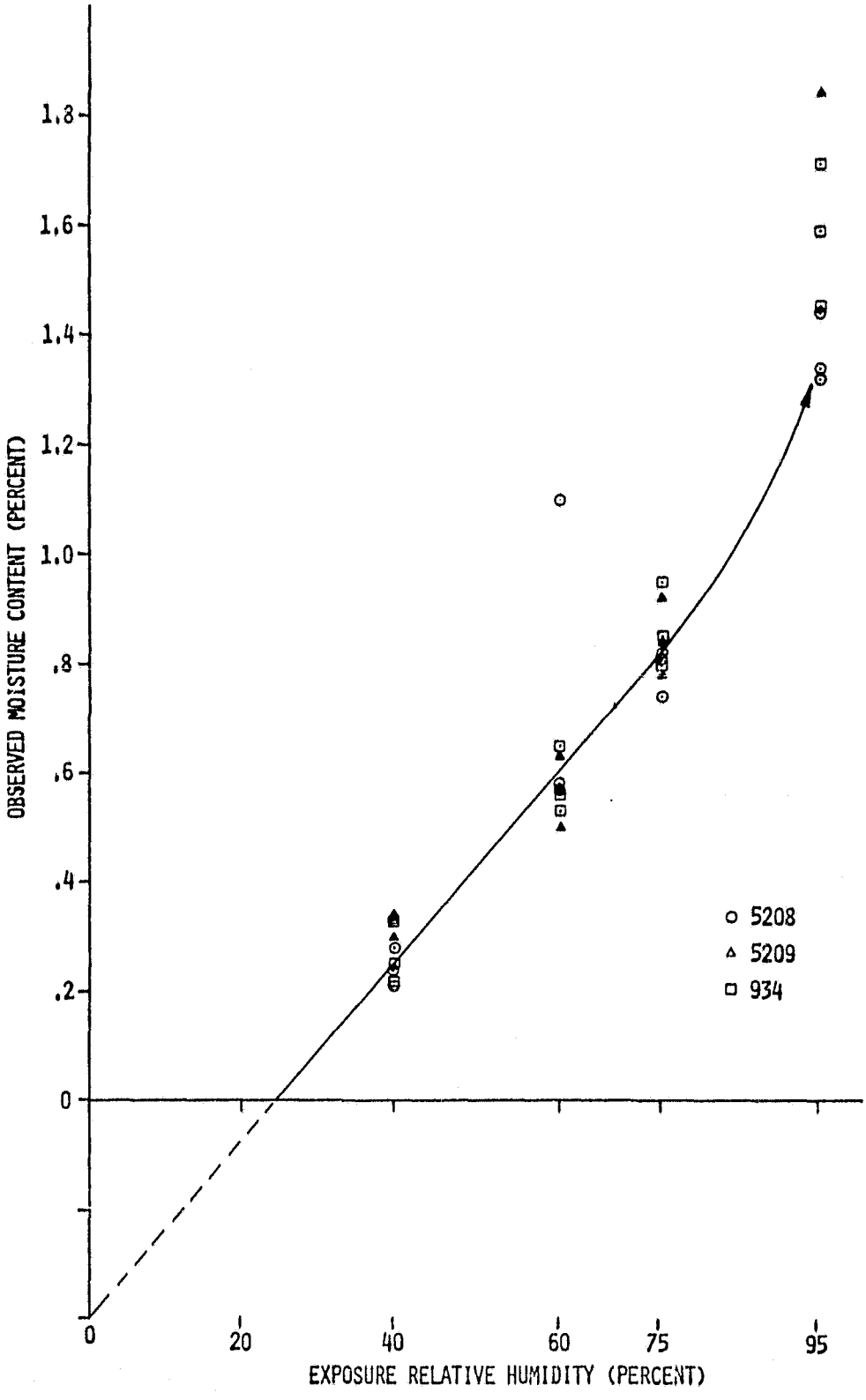


Figure 5-3. Moisture Content as a Function of Humidity

5.2.4 EFFECT OF WEATHEROMETER CYCLING

No additional mechanical testing was performed during the reporting period. The next set of tests is scheduled for mid September, 1980 and will be included in the next Quarterly Report. A second set of Weatherometer exposed specimen surface photos has been received. An earlier set of similar photos was shown in The Sixth Quarterly Progress Report. The initial set showed that the Narmco 5209 specimens had lost less surface resin than either of the two 350° curing systems. This was essentially what the weight loss curves had shown. At the end of a nominal 6 months of exposure, all three systems had lost similar amounts of weight and all three had stopped losing weight. This was taken to mean that all three systems had lost most or all available surface resin and were now being shielded by the first layer of fibers. The photos, shown in Figure 5-4, again provide confirmation. All three resins appear to have lost approximately the same amount of resin and there is no longer a visible difference between systems.

5.2.5 EFFECT OF SIMULATED GROUND-AIR-GROUND CYCLING

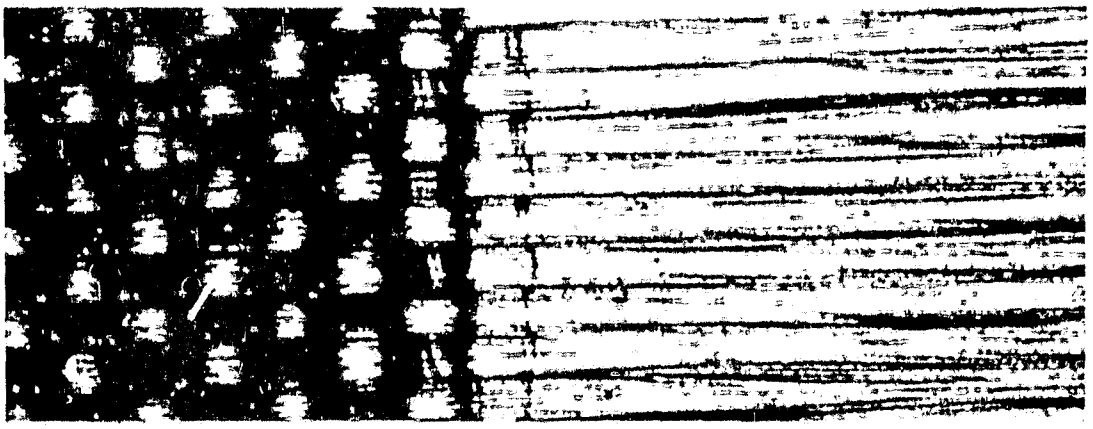
This program is intended to duplicate, in the lab, the environment experienced by a commercial transport aircraft operating out of a hot, moist, tropical climate.

Specimens exposed to a nominal 6 months of ground-air-ground cycling were tested during this reporting period. A listing of the mechanical test results is shown in Table 5-17. Testing at 180°F generally produced a greater strength loss than testing at room temperature. The one exception to this was the flexural strength of T300/5208.

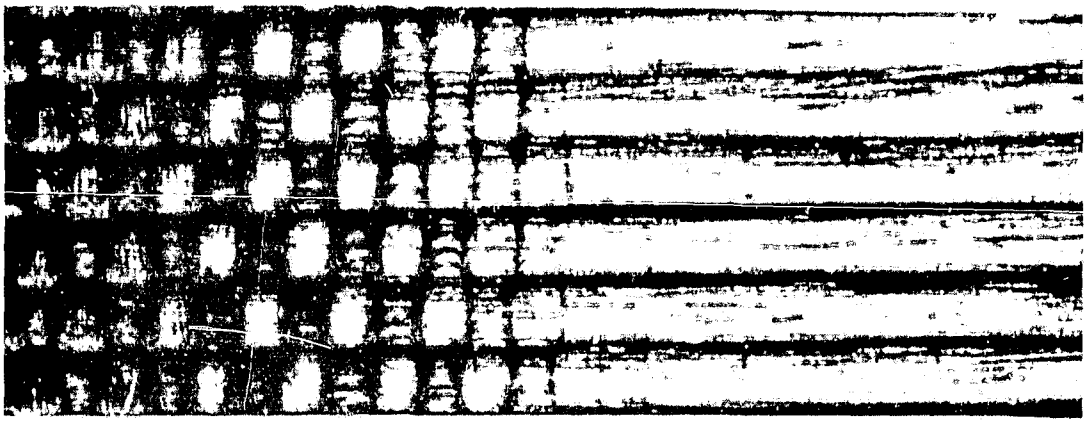
In light of previous reports showing a weight gain-plateau-gain pattern the strength losses noted here led to concern that a freeze/thaw damage mechanism was gradually cracking the specimens. Several photo micrographs were taken of these specimens to look for possible cracks, but no macro or micro cracking was visible. Figure 5-5 shows one of these micrographs.

A second possible explantion for the gain-plateau-gain weight pattern concerns the exposure chamber itself. Chamber reliability has been very poor. Periodic scheduled and unscheduled maintenance have caused several prolonged shutdowns. The exact environment experienced by the specimens during these shutdowns is uncertain since maintenance procedures have been far more extensive than originally anticipated. The continued practical availability of this chamber is currently being investigated. At a minimum, it will be necessary to establish a procedure for removing the specimens from the chamber during repairs.

The measured moisture contents of these specimens ranged from 0.7% to 1.0%. Most of the observed strength reductions can be attributed to the presence of the moisture.



5208



5209

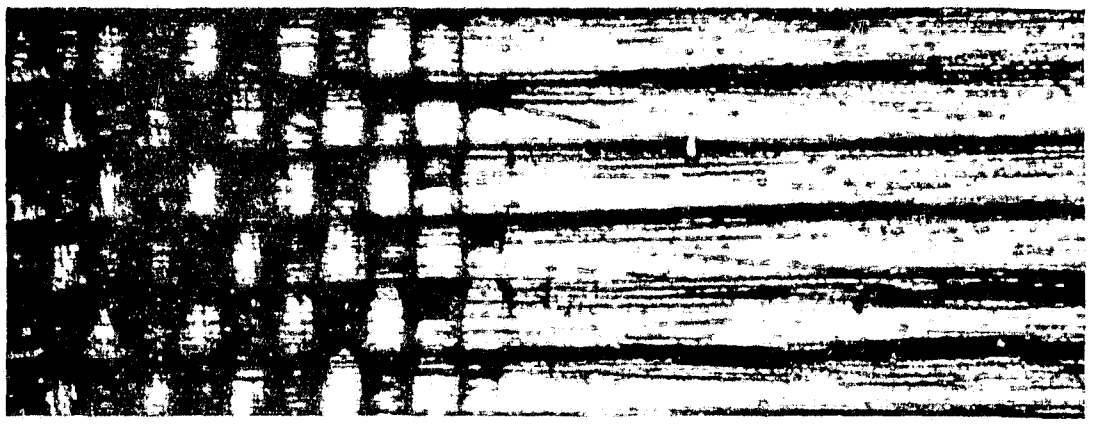


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Figure 5-4. Nominal 6 Month Weatherometer Exposed Specimen Surfaces

Table 5-17. Physical and Mechanical Test Results, Nominal 6 Months Simulated G-A-G Cycling

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	FAILURE LOAD (POUNDS)	TEST TEMPERATURE (^{o}F)
ASBLGOF -1	0.0984	.2500	482.0	70
ASBLGOF -2	0.0977	.2499	464.0	70
ASBLGOF -3	0.0951	.2510	485.0	70
ASBLGOF -4	0.0974	.2491	434.0	70
ASBLGOF -5	0.0963	.2505	492.0	70
ASBLGOF -6	0.0966	.2507	354.0	180
ASBLGOF -7	0.0949	.2503	402.0	180
ASBLGOF -8	0.0964	.2504	428.0	180
ASBLGOF -9	0.0938	.2492	372.0	180
ASBLGOF -10	0.0979	.2508	410.0	180
BSBLGOF -1	0.0998	.2508	362.0	70
BSBLGOF -2	0.1033	.2508	450.0	70
BSBLGOF -3	0.1043	.2491	420.0	70
BSBLGOF -4	0.1022	.2511	436.0	70
BSBLGOF -5	0.1022	.2485	408.0	70
BSBLGOF -6	0.1030	.2493	306.0	180
BSBLGOF -7	0.0975	.2423	296.0	180
BSBLGOF -8	0.1013	.2508	322.0	180
BSBLGOF -9	0.1031	.2489	326.0	180
BSBLGOF -10	0.1038	.2491	312.0	180
CSBLGOF -1	0.1090	.2487	544.0	70
CSBLGOF -2	0.1099	.2456	548.0	70
CSBLGOF -3	0.1052	.2490	494.0	70
CSBLGOF -4	0.1056	.2464	528.0	70
CSBLGOF -5	0.1080	.2490	530.0	70
CSBLGOF -6	0.1103	.2470	428.0	180
CSBLGOF -7	0.1109	.2495	476.0	180
CSBLGOF -8	0.1082	.2468	418.0	180
CSBLGOF -9	0.1085	.2451	456.0	180
CSBLGOF -10	0.1071	.2492	462.0	180

Table 5-17. Physical and Mechanical Test Results, Nominal 6 Months Simulated G-A-G Cycling (Concluded)

SPECIMEN IDENTIFICATION NUMBER	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	FAILURE LOAD (POUNDS)	TEST TEMPERATURE (^{o}F)
AFLLGOF -1	0.0661	0.5020	111.5	70
AFLLGOF -2	0.0668	0.5041	113.5	70
AFLLGOF -3	0.0662	0.4998	110.0	70
AFLLGOF -4	0.0670	0.5000	115.5	70
AFLLGOF -5	0.0671	0.5028	119.0	70
AFLLGOF -6	0.0660	0.5018	107.5	180
AFLLGOF -7	0.0670	0.4991	107.5	180
AFLLGOF -8	0.0660	0.5019	111.5	180
AFLLGOF -9	0.0668	0.5003	114.0	180
AFLLGOF -10	0.0661	0.5021	105.0	180
BFLLGOF -1	0.0629	0.4972	97.0	70
BFLLGOF -2	0.0628	0.4945	106.0	70
BFLLGOF -3	0.0630	0.4994	103.0	70
BFLLGOF -4	0.0639	0.4984	113.5	70
BFLLGOF -5	0.0628	0.4971	107.0	70
BFLLGOF -6	0.0637	0.5004	87.5	180
BFLLGOF -7	0.0630	0.4951	81.0	180
BFLLGOF -8	0.0629	0.4970	74.5	180
BFLLGOF -9	0.0637	0.4920	78.0	180
BFLLGOF -10	0.0633	0.4920	71.0	180
CFLLGOF -1	0.0678	0.4988	140.0	70
CFLLGOF -2	0.0666	0.4971	139.5	70
CFLLGOF -3	0.0670	0.4975	134.0	70
CFLLGOF -4	0.0667	0.5002	122.0	70
CFLLGOF -5	0.0646	0.4993	124.0	70
CFLLGOF -6	0.0641	0.4978	100.5	180
CFLLGOF -7	0.0660	0.4988	109.5	180
CFLLGOF -8	0.0651	0.4974	101.5	180
CFLLGOF -9	0.0677	0.4995	116.5	180
CFLLGOF -10	0.0659	0.4988	109.5	180

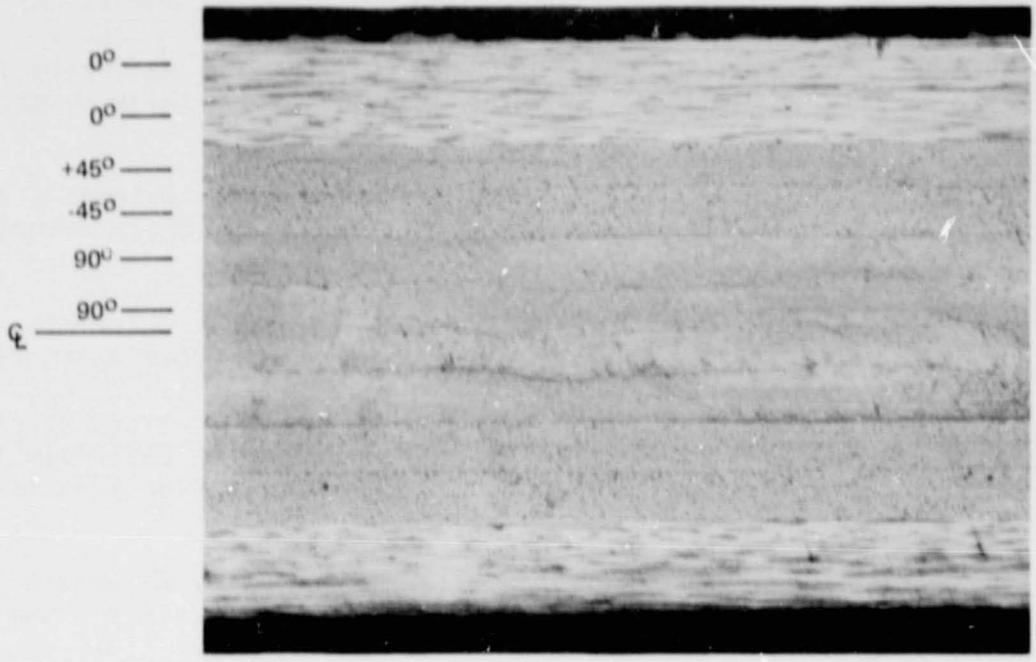


Figure 5-5. Flexure Specimen Edge After Nominal 6 Months Simulated G-A-G Cycling

6.0 REFERENCES

1. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, First Quarterly Progress Report. NASA CR-165641, February 1978.

2. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Second Quarterly Progress Report. NASA CR-165642, May 1978.

3. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Third Quarterly Progress Report. NASA CR-165643, August 1978.

4. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Fourth Quarterly Progress Report. NASA CR-165644, December 1978.

5. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Fifth Quarterly Progress Report. NASA CR-165645, February 1978.

6. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Sixth Quarterly Progress Report. NASA CR-165646, May 1979.

7. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Seventh Quarterly Progress Report. NASA CR-165647, August 1979.

8. "Environmental Exposure Effect on Composite Materials for Commercial Aircraft", NAS1-15148, Eighth Quarterly Progress Report. NASA CR-165648, November 1979.

APPENDIX A

TEST SPECIMEN DRAWINGS

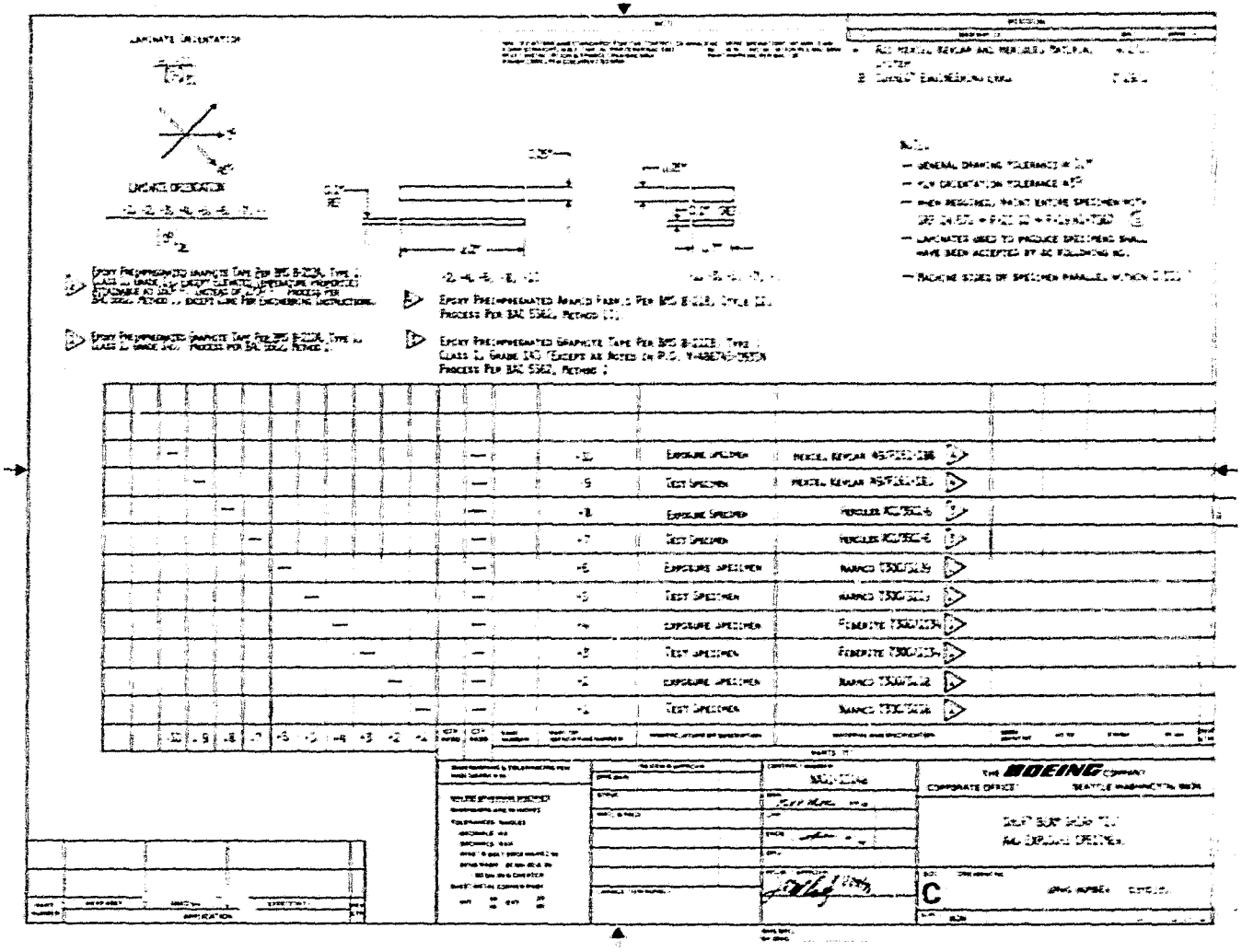


Figure A-1.

Figure A-2.

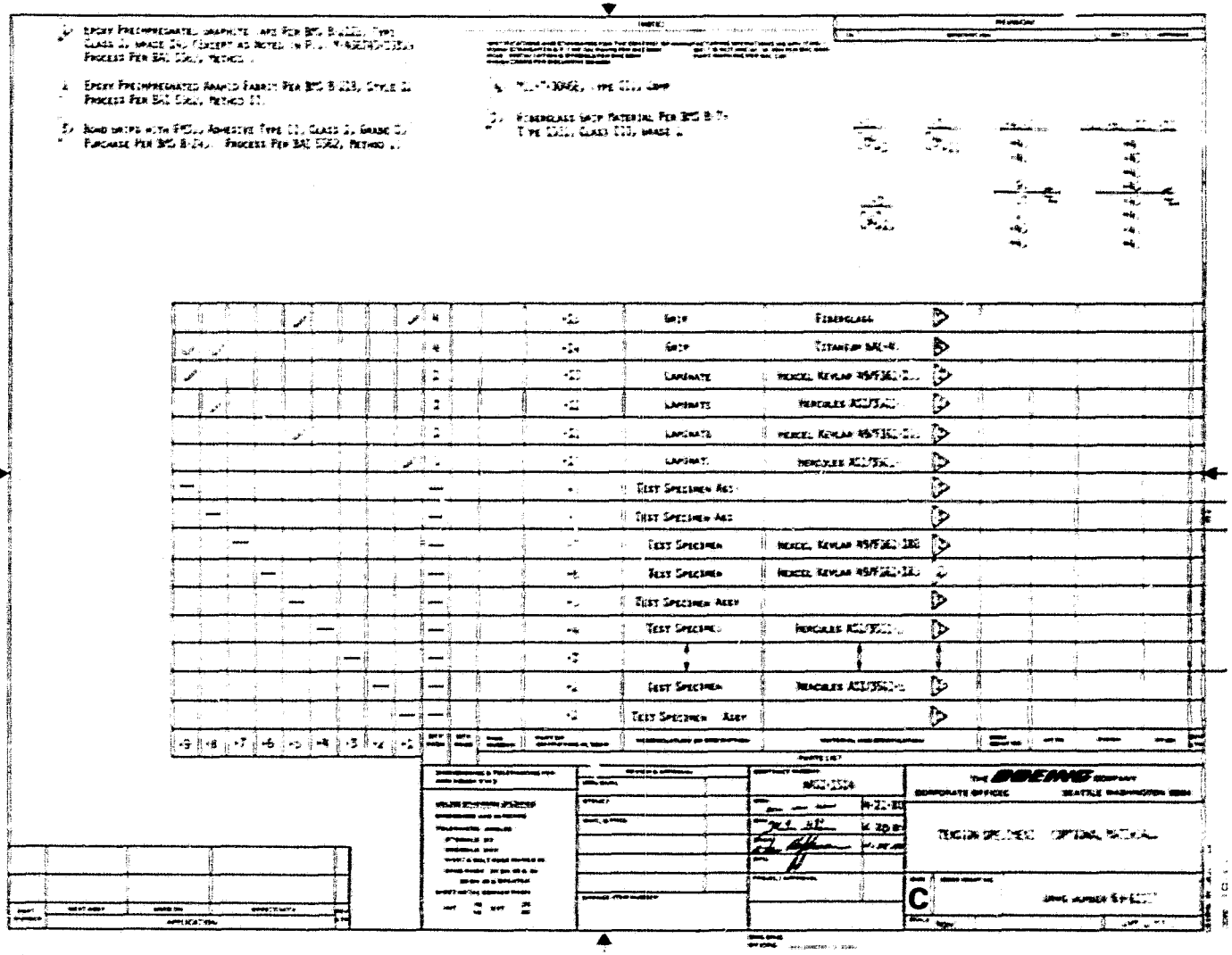
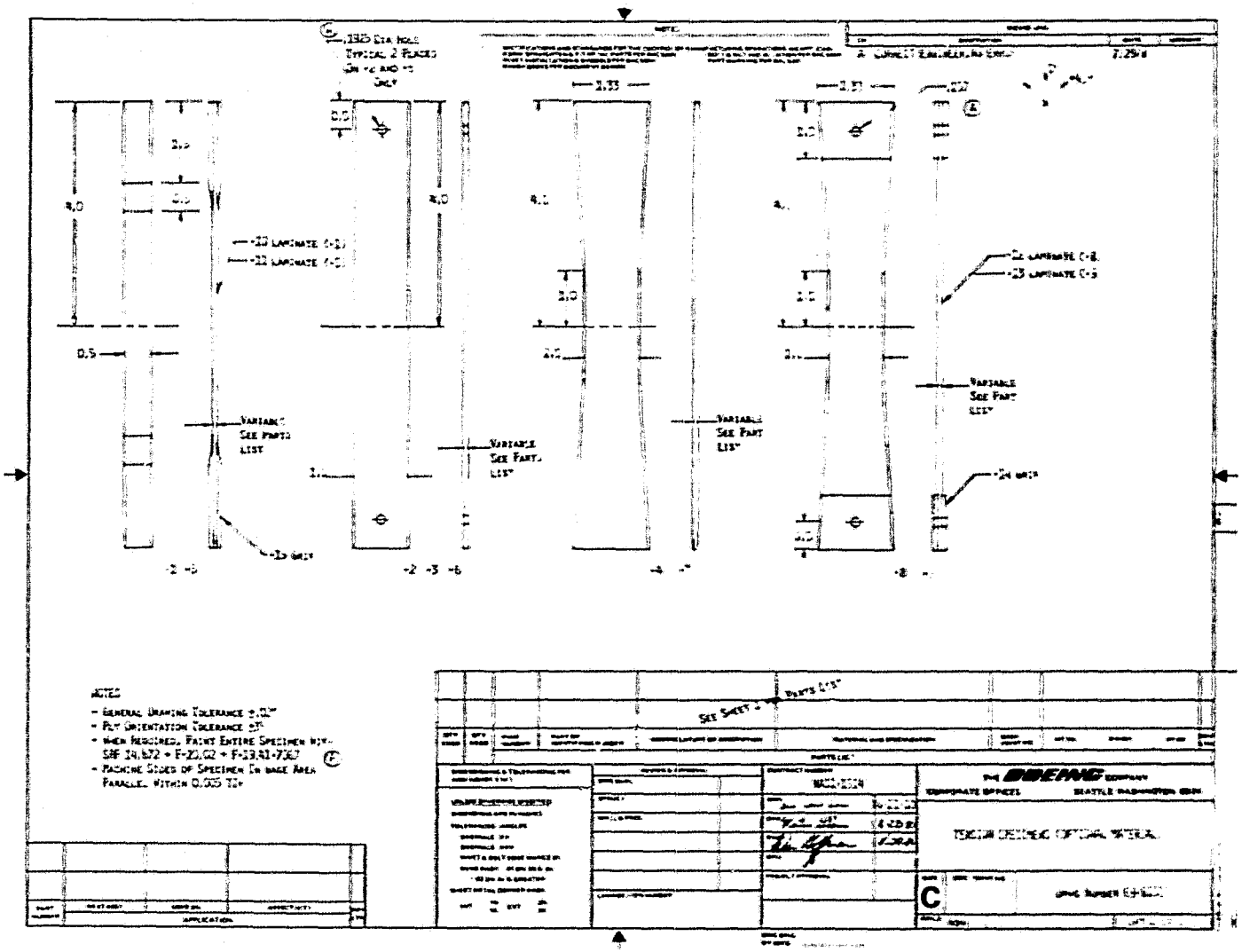


Figure A-3.



FigureA-3. (Concluded)

Figure A-4.

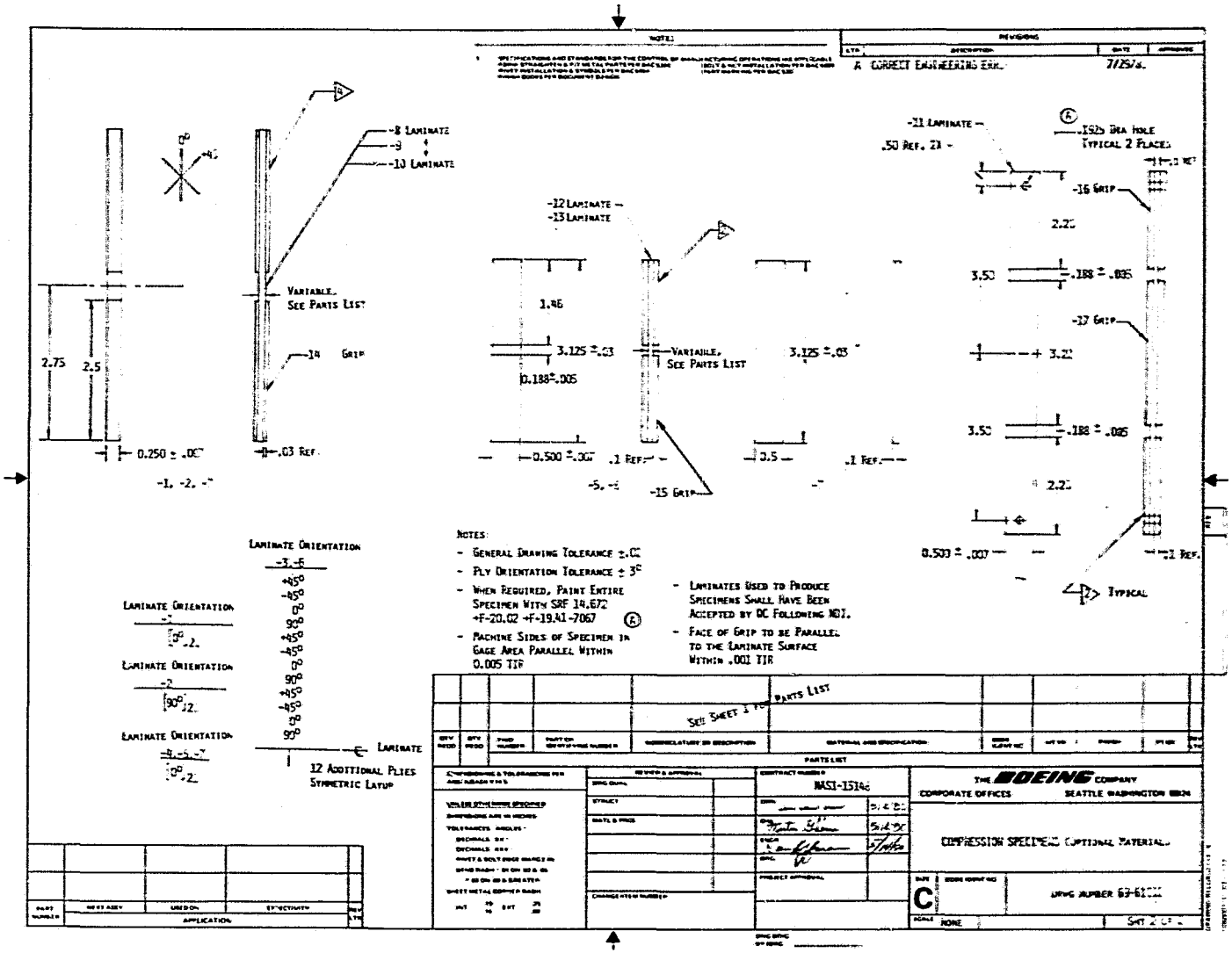


Figure A-4. (Concluded)